TORONTO AND REGION REMEDIAL ACTION PLAN

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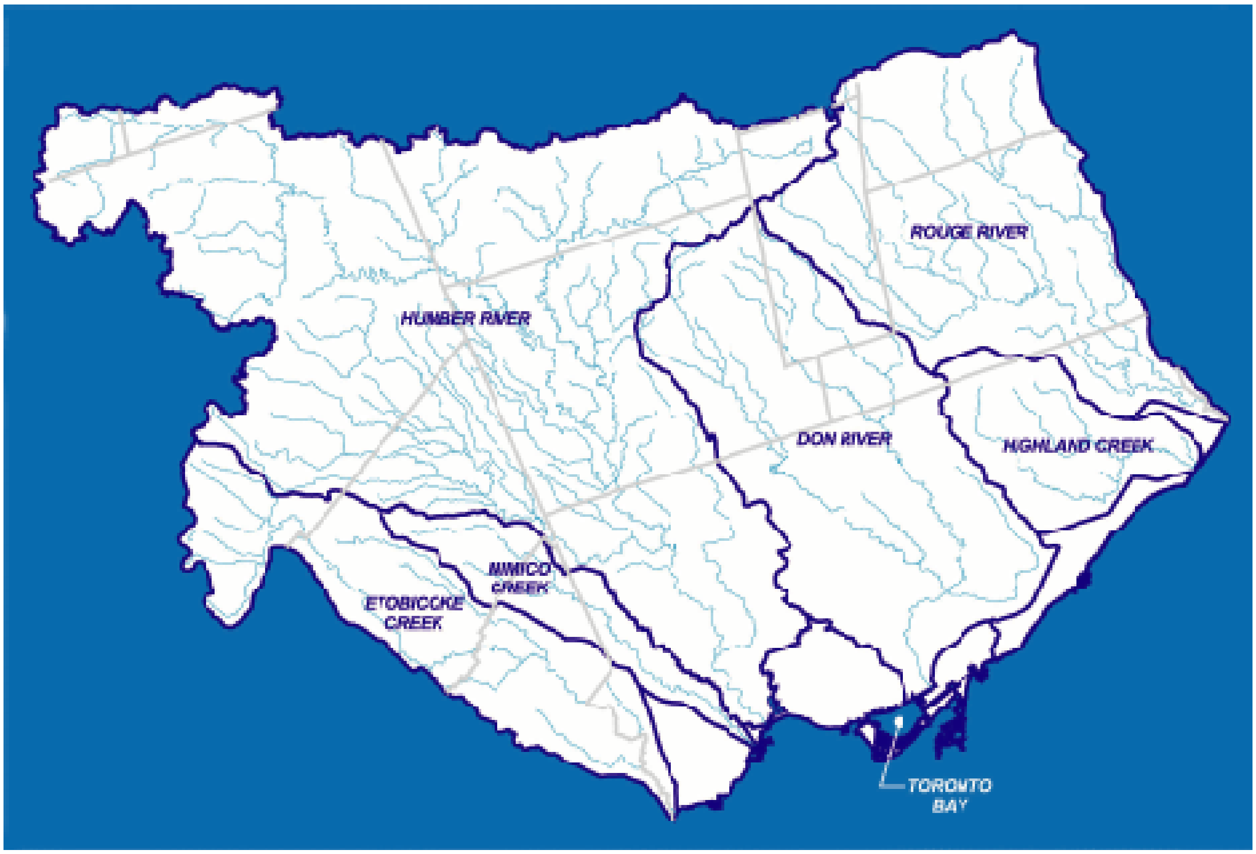

ASSESSMENT OF SIX TRIBUTARY DISCHARGES TO THE TORONTO AREA WATERFRONT

VOLUME 1: PROJECT SYNOPSIS AND SELECTED RESULTS

Remedial Action Plan
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Canada Ontario

ASSESSMENT OF SIX TRIBUTARY DISCHARGES TO THE TORONTO AREA WATERFRONT

VOLUME 1:

PROJECT SYNOPSIS AND SELECTED RESULTS

Report prepared for
The Toronto and Region Remedial Action Plan

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Foreword

This report completes a series of technical documents prepared on behalf of the Toronto RAP which have also covered assessment of wet and dry weather discharges from sewers and sewage treatment plants. Although the data in this report have been released previously in various forms over the past three years to partners in the Toronto RAP, until now they have not been summarized and submitted for formal publication and distribution to a wider audience.

This summary document containing selected results has been prepared for widespread distribution. A companion document entitled: *Assessment of Six Tributary Discharges To the Toronto Area Waterfront Volume 2: Technical Appendix and Data Listing* is available for those readers who wish to have access to the entire data set.

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1.0 INTRODUCTION

1.1 Background

The Toronto Waterfront has been designated as one of 16 remaining areas of concern in Ontario by the International Joint Commission (IJC). The IJC has recommended the development of a Remedial Action Plan (RAP) for the restoration of the waterfront to its desired uses. The RAP is to include a description of the causes of pollution and to propose measures for remediation. In developing the Toronto and Region RAP, the RAP Team has recognized a deficiency in contaminant and flow data for various discharges to the waterfront.

The Toronto Waterfront, extending west from Etobicoke Creek and east to the Rouge River, receives flow from numerous sources including:

(a) effluent from three water pollution control plants (WPCP),

(b) backwash water from three water filtration plants (FP),

(c) over 100 combined and storm sewer outfalls (CSO and SS), and

(d) six watersheds (Humber, Don and Rouge Rivers, and Etobicoke, Mimico and Highland Creeks).

A number of studies have been initiated in support of the RAP development to investigate contaminant discharges from these sources. Results from the WPCP, FP, and CSO/SS studies have already been documented (Snodgrass and D'Andrea 1993, Paul Theil Associates Limited and Beak Consultants Limited 1995, Maunder and Whyte 1995, and Aquafor Beech Limited 1997). This report documents results of a study initiated in late 1990 to evaluate the chemical composition and contaminant mass discharges of the six watersheds.

1.2 Study Objectives

The primary objectives of the study were to:

(1) Identify the chemical constituents present in each tributary (including conventional water quality parameters, bacteria, nutrients, heavy metals and trace organic compounds),

(2) Estimate mean contaminant concentrations under dry and wet weather conditions,

(3) Compare contaminant concentrations between watercourses,

(4) Estimate the seasonal and annual contaminant mass discharge for each watercourse,

A strong emphasis was placed on the analysis of trace organic compounds which involved

special sample collection and analytical procedures. In addition, non-traditional techniques were used in the analysis of data sets containing data at or below the analytical detection limit.

Results from this study are intended to assist in the development, prioritization and design of remedial options and will form a data base by which the effectiveness of remedial measures can be evaluated once implemented.

1.3 Description of the Watersheds

Table 1.1 provides a summary of drainage area and land use characteristics by watershed. The Oak Ridge Moraine, stretching across the northern boundary of the Toronto and Region RAP, is the divide for watercourses draining to Lake Ontario and those draining to the north. With the exception of Highland Creek, the watersheds, extend across several municipal and regional boundaries. It should be emphasized that while only the most downstream locations were monitored in this study, the cumulative effect of inputs from all upstream sources will be reflected in the data. Watershed drainage areas are presented in Figure 1.1. By drainage area the watersheds ordered in decreasing size are: Humber River, Don River, Rouge River, Etobicoke Creek, Highland Creek and Mimico Creek.

From Table 1.1, the watersheds can be ordered by decreasing levels of urbanization as follows: Highland Creek, Mimico Creek, Don River, Etobicoke Creek, Humber River and Rouge River. Generally, the land use activity in these watercourses can be characterized by predominantly highly developed urban areas in the lower reaches, and an urbanizing fringe extending north of metropolitan Toronto. Further upstream, the evolving rural landscape supports agricultural activity and includes many small towns. In most cases, the river and creek valleys in the lower urbanized reaches are generally open space which interconnect parkland.

TABLE 1.1: WATERSHED LAND USE CHARACTERISTICS (TRCA 1998)

LAND USE	WATERSHED					
	ETOBICOKE CREEK	MIMICO CREEK	HUMBER RIVER	DON RIVER	HIGHLAND CREEK	ROUGE RIVER
Total Area (km^2)	211	77	908	360	102	327
Industrial/Commercial	24%	35%	6%	18%	23%	5%
Institutional	7%	9%	1%	6%	4%	1%
Residential	22%	33%	17%	43%	54%	12%
Open Space	24%	23%	30%	31%	19%	15%
Agricultural	23%	0%	46%	2%	0%	67%

1.4 Description of Contaminant Sources

As previously noted, the watersheds are heavily urbanized and the sources of contaminants to each watershed are diverse. Table 1.2 presents an estimate of the number of storm sewer and combined sewer overflow outfalls which discharge to each of the watercourses. These sewers can be significant sources of contaminants under dry and wet weather conditions. Under dry weather conditions contaminant sources can include: sanitary sewer cross connections, infiltration from the sanitary sewer system, accidental or deliberate spills to road side catch basins, industrial cooling water, and excess surface watering (i.e. lawns, washing on paved surfaces, etc.).

Under wet weather conditions there are numerous contaminant sources to storm sewers and combined sewer overflows. These sources are related to both local land use activities and atmospheric wet and dry deposition (where the contaminants may originate from local or remote emissions). Atmospheric and local land use activity sources typically include:

(a) combustion emissions from industrial activities, incinerators, heating (including residential) and power generation activities, and vehicular traffic;

(b) heavy metal emissions from electrical and chemical industries, smelting, refining, welding and spray coating operations; and

(c) airborne emissions of pesticides in agricultural and residential applications.

(d) chemical (fertilizers and pesticides) applications in urban areas;

(e) vehicular traffic byproducts such as exhaust, brake and tire wear, fuel and engine oil leaks or spills, corrosion, deicing chemicals;

(f) wash off from commercial/industrial storage areas; and

(g) faecal material from wildlife and domestic animals.

Sources of contaminants in combined sewer overflows include all the above-mentioned sources as well as contaminants associated with wastes in the sanitary stream from industrial, commercial and residential discharges.

Other sources of contaminants or water quality degradation in watercourses can include: stream bank erosion, erosion from construction sites, agricultural runoff (fertilizers, pesticides and animal faeces), landfill leachate, and sewage treatment plant effluent.

Contaminant inputs to each of the six Toronto area watersheds under investigation will be influenced by a range of local land use factors and point sources. For example, Etobicoke Creek flows along the western perimeter of Lester B. Pearson International Airport and most of the storm drainage (1,547 ha) from the airport lands is routed to the creek. Mimico Creek flows east of the airport and receives approximately 180 ha of storm drainage from the airport. Effluent

flow from York Region's Kleinburg Water Pollution Control Plant (0.2 MLD) is discharged to the northern portion of the Humber River watershed while the Don River receives effluent flow from the City of Toronto's North Toronto Water Pollution Control Plant (45 MLD) upstream of Pottery Road.

1.5 Study Approach

The study involved the collection of water samples from each watercourse during dry and wet weather, compiling flow data collected by Environment Canada and then compiling statistical summaries of flow, contaminant concentrations and contaminant loadings (mass discharges). Each sample was collected as a 24 hour time composite. Samples were collected from each watercourse for a minimum one year period during a two year monitoring program between 1991 and 1992. Special consideration was given to the sample volume requirements necessary to detect priority trace organic contaminants at low concentrations. Large volume (100 litre) samples were collected in order to achieve reasonably low analytical detection limits for these compounds, while an additional sample volume of about 20 litres was collected for the analysis of other contaminants of interest.

Sampling stations were established as close to the mouth of each watercourse as possible, upstream of lake backwater effects. In all cases, samples were collected by means of an automatic wastewater sampler. The intake line was positioned at approximately mid-depth and as close to the middle of the watercourse as possible. Sampling equipment was installed inside Environment Canada flow gauging stations at the Don River and Etobicoke Creek stations. At all other sampling stations equipment was installed in secure, portable huts.

The parameters analysed in this study included the following major groupings: general chemistry, organochlorine pesticides/PCBs, nutrients, chlorophenols, chlorobenzenes, bacteriology, volatile organics, metals, and polynuclear aromatic hydrocarbons (PAHs).

With the exception of the large volume (100 litre) trace organics analyses of chlorobenzenes, organochlorine pesticides, polynuclear aromatic hydrocarbons (PAHs) and total PCBs, the Ontario Ministry of the Environment, Laboratory Services Branch performed the chemical analysis for all compounds. Analytical methodologies described in MOE (1988) were used in these analyses.

Mann Testing Laboratories performed the chemical analysis of the large volume samples for the above-mentioned trace organic compounds. The analytical procedure involved using a Goulden Extractor for the solvent extraction of the unfiltered sample (liquid-liquid extraction using DCM). The concentration, cleanup and analysis using a dual column/dual electron capture detector followed the methodology described in MOE (1988); except for the analysis of PAH compounds which used a mass spectrometer detector.

Median dry and wet weather concentrations have been computed and presented in this summary document. Probability distribution estimation (PDE) techniques were used to estimate the mean and corresponding confidence interval for the data sets containing “left-censored” data (i.e. results below the limit of detection) for the complete data summary included in the companion document to this report: *Volume 2: Technical Appendix and Data Listing*. These techniques use the probability distribution of the non-censored data (data above the detection limit) to estimate the statistical properties of the entire data set. One of these techniques, the maximum likelihood estimation (MLE) method is widely accepted for the statistical description of left-censored water chemistry data (Cohen 1959, Gilbert 1987, and El-Sharaawi and Dolan 1989), and was one technique used in this study. It provides an estimate of the mean and standard deviation of the data set by using estimates of the statistical properties of the non-censored data. It is recommended for use when up to 80% of the distribution is censored and where there is a minimum of three non-censored values. A more traditional approach such as substituting a fraction (generally 0.5) of the analytical detection limit value for those values which were at or below the detection limit was used when the data characteristics did not permit the application of the PDE techniques. This approach was used to provide only qualitative mean estimates of the data. Confidence intervals were not presented because they are biassed by the substituted data.

Contaminant mass loading estimates were generated for each tributary using the Beale Ratio Estimator technique; a well established approach for the estimation of tributary contaminant mass loadings when continuous flow data and discrete water chemistry data are available (Dolan *et al.* 1981). This method derives the ratio of the mean of measured loads to the mean of their corresponding flow measurements which is then combined with the mean of actual flow to yield an overall loading estimate. The estimate can be improved by partitioning the data set into strata based on flow driven relationships with contaminant concentration. In this study, the Beale Ratio Estimator was used with dry weather (“low”) and wet weather (“high”) flow strata (except for the Rouge River which used one low flow stratum and two high flow strata) to generate estimates of mass discharges and the associated 95% confidence interval for those cases where the water chemistry sample size was sufficiently large to provide reasonable estimates. For most tributaries this was possible for estimations of annual, and wet and dry weather loadings.

Results presented here should be considered representative of relative loadings among tributaries rather than long-term average conditions since this technique was applied using flow and water chemistry data collected during this study period only. Each tributary was sampled for a period of one year within the overall two year window and extreme conditions such as large storms or lower than average spring flows resulting from below average snow accumulation (as was experienced in 1992) will have influenced the estimates of contaminant mass loadings.

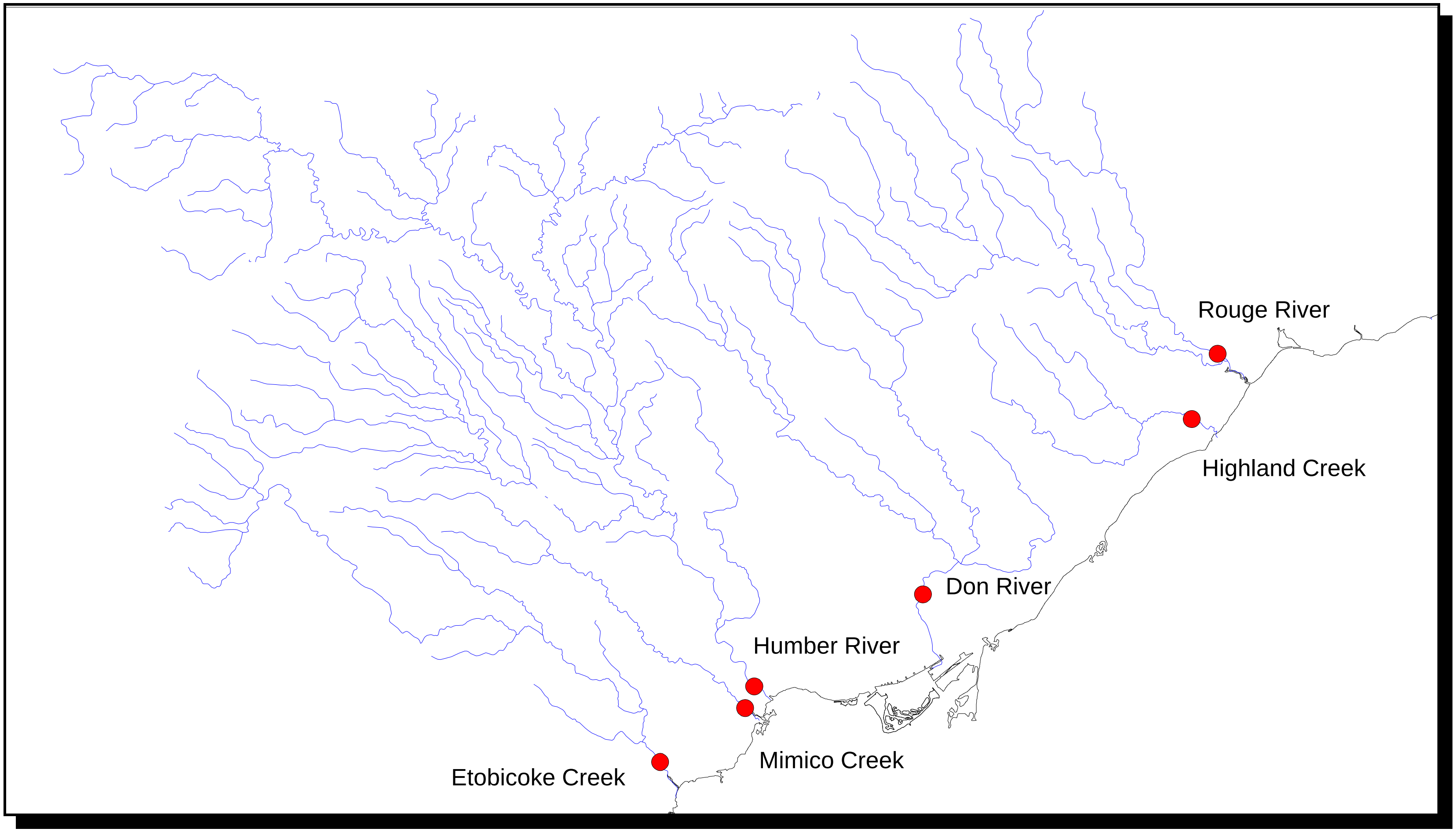

Figure 1.1 Drainage Basin Areas and Sampling Locations

TABLE 1.2: SEWER OUTFALL DISCHARGES WITHIN TORONTO TO EACH WATERSHED (Environment Canada *et al.* 1988)

WATERSHED	NUMBER OF SEWER OUTFALLS		TOTAL
	Storm Sewers	CSOs	
Etobicoke Creek	57	0	57
Mimico Creek	194	0	194
Humber River	619	5	624
Don River	872	30	902
Highland Creek	473	0	473
Rouge River	13	0	13

2.0 RESULTS FOR SELECTED CONTAMINANTS

Complete wet and dry weather water quality results (means, 95% confidence intervals) for all 76 physical parameters, nutrients, bacteria, metals, pesticides, polynuclear aromatic hydrocarbons (PAHs), and volatiles are summarized in *Volume 2: Technical Appendix and Data Listing* for all six tributaries. Volume 2 also contains complete wet weather, dry weather, and annual loading summaries (with estimated error) for all six tributaries.

Of the 76 parameters listed in *Volume 2*, 47 have Provincial Water Quality Objectives (PWQOs) and Table 2.1 provides a complete summary identifying frequencies of detection in excess of PWQOs. The table demonstrates that of the 47 water quality parameters having PWQOs, 22 of them were never detected at concentrations greater than PWQOs in any dry or wet weather samples from these six tributaries.

Results from Table 2.1 can also be used to select a subset of “indicator” parameters from the complete list of 76 physical parameters to illustrate the range of available results. The list in the table has been sorted by average frequency of detection above PWQOs for each parameter and has been used to select the following eight: Suspended Solids (SS; not included in Table 2.1 but a useful surrogate for a wide range of hydrophobic substances such as metals and trace organics), Total Phosphorus (TP), *E. Coli*, Copper (Cu), Lead (Pb), Aldrin/Dieldrin, Phenanthrene, and

Total PCB (PCB). These general indicators were selected as the most frequently detected representatives of pollutant classes (e.g. nutrients, metals, trace organics) having PWQOs (or interim PWQOs) greater than (or equal to) analytical detection limits.

These data have been summarized to provide a comparison of wet and dry weather concentrations with Provincial Water Quality Objectives (PWQOs) across all tributaries along with a comparison of dry weather, wet weather, and annual loadings.

2.1 Detection Frequencies Above PWQOs

Figure 2.1 summarizes detection frequency information for seven of the eight selected parameters (excluding suspended solids which has no PWQO). The general picture which emerges from this cross section of results is that wet weather concentrations of all seven parameters consistently exceed PWQOs. The exceptions were Aldrin/Dieldrin (which ranged from 0%>PWQO at Mimico Creek and the Rouge river to just over 40%>PWQO at the Don River), and PCB (which ranged from less than 10% at Highland Creek and the Rouge River to just over 80% at the Don River). Dry weather observations were more variable depending upon location and parameter. Dry weather observations in excess of PWQOs were greater than 50% for: TP at Mimico Creek and the Don River; E. Coli everywhere except the Don River and Rouge River; Cu and Pb everywhere (except Cu at the Rouge River). Dry weather observations in excess of PWQOs were nil for Aldrin/Dieldrin at all locations, and were less than 10% for PCB at Mimico Creek, Highland Creek, and the Rouge River.

TABLE 2.1: FREQUENCY OF SAMPLES EXCEEDING PROVINCIAL WATER QUALITY OBJECTIVES

PARAMETER (* denotes *interim* PWQO)	PWQO (ug/L)	ETOBICOKE CREEK DRY	ETOBICOKE CREEK WET	MIMICO CREEK DRY	MIMICO CREEK WET	HUMBER RIVER DRY	HUMBER RIVER WET	DON RIVER DRY	DON RIVER WET	HIGHLAND CREEK DRY	HIGHLAND CREEK WET	ROUGE RIVER DRY	ROUGE RIVER WET
*Fluoranthene**	0.0008	78%	100%	88%	92%	100%	95%	78%	100%	75%	100%	80%	87%
E. Coli (count/100mL)	100.00	90%	100%	100%	100%	100%	100%	32%	89%	91%	100%	44%	90%
*Aluminum**	75.00	62%	100%	72%	100%	81%	100%	86%	100%	42%	93%	91%	100%
*Lead**	5.00	86%	94%	78%	93%	90%	88%	86%	90%	58%	100%	64%	88%
Copper	5.00	81%	94%	78%	93%	81%	85%	86%	100%	50%	100%	18%	81%
*Chrysene**	0.0001	50%	93%	81%	100%	84%	95%	61%	100%	25%	77%	50%	60%
*Total phosphorus**	30.00	38%	94%	94%	100%	50%	88%	100%	100%	17%	80%	18%	81%
Iron	300.00	29%	94%	39%	93%	52%	92%	100%	100%	25%	80%	27%	88%
*Cadmium**	0.50	67%	75%	61%	67%	67%	62%	64%	55%	25%	67%	36%	38%
*Benzo[a]anthracene**	0.0004	17%	79%	56%	100%	53%	91%	13%	100%	0%	69%	30%	53%
*Benzo[g,h,I]perylene**	0.00002	28%	79%	44%	92%	26%	82%	26%	100%	0%	77%	0%	53%
Silver	0.10	43%	44%	61%	40%	52%	46%	64%	52%	42%	13%	55%	31%
*Zinc**	20.00	24%	69%	33%	87%	24%	69%	27%	90%	0%	60%	0%	19%
PCB	0.001	38%	63%	6%	67%	32%	44%	13%	84%	0%	8%	9%	6%
*Phenanthrene **	0.030	6%	57%	25%	69%	5%	36%	13%	61%	0%	46%	0%	47%
*Perylene**	0.00007	6%	14%	19%	77%	5%	41%	0%	61%	0%	46%	0%	33%
*Anthracene**	0.0008	6%	36%	25%	62%	5%	45%	9%	67%	0%	23%	0%	7%
*Dibenzo[a,h]anthracene**	0.002	6%	14%	6%	69%	5%	27%	0%	44%	0%	23%	0%	13%
Aldrin/Dieldrin	0.001	0%	13%	0%	0%	0%	8%	0%	42%	0%	15%	0%	0%
*Benzo[a]pyrene**	0.210	0%	21%	0%	15%	0%	14%	0%	11%	0%	0%	0%	0%
DDT+	0.003	0%	13%	0%	0%	0%	0%	0%	37%	0%	0%	0%	0%
Nickel	25.00	5%	13%	0%	0%	0%	8%	0%	5%	0%	0%	0%	6%
*Arsenic**	5.00	0%	0%	0%	0%	5%	0%	0%	5%	0%	13%	0%	6%
*Fluorene**	0.200	0%	0%	6%	8%	0%	0%	0%	0%	0%	0%	0%	0%
Lindane	0.010	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Chlordane	0.060	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Methoxychlor (DMDT)	0.040	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
*Mercury**	0.20	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Heptachlor+Heptachlor epoxide	0.001	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Pentachlorophenol	0.500	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Pentachlorobenzene	0.030	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1,2,3-Trichlorobenzene	0.900	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1,2,4-Trichlorobenzene	0.500	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1,3,5-Trichlorobenzene	0.650	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1,2,4,5-Tetrachlorobenzene	0.150	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Napthalene	7.000	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1-Methylnapthalene	2.000	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2-Methylnapthalene	2.000	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Beryllium	1100.00	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Chromium	100.00	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Selenium	100.00	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
*Bromoform**	60.0	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
*Tetrachloroethylene**	50.0	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
*Toluene**	0.8	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
*1,1,1-Trichloroethane**	10.0	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
*Trichloroethylene**	20.0	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
*p-Xylene**	30.0	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%

2.2 Contaminant Concentration Characteristics

Median contaminant concentrations are compared with Provincial Water Quality Objectives (PWQOs) as a means of evaluating the potential severity of water quality conditions. Figure 2.2 summarizes concentration data for the eight selected parameters described above.

Median Cu and Pb concentrations exceeded PWQOs under both wet and dry conditions at all locations, as did median wet weather contaminant concentrations of TP and *E. Coli*. Median concentrations of PCBs exceeded the PWQO of 1.0 ng/L under wet weather conditions at three of the tributaries only (Etobicoke Creek, Mimico Creek, and the Don River) as did median wet weather concentrations of Phenanthrene . It should be noted that final PWQOs are not yet available for many of the other trace organics detected in this study and consequently their significance cannot be directly evaluated in this way. Many of these substances have been identified as high priority "Persistent Organic Pollutants" by MOE, Environment Canada, and the International Joint Commission due to their bioaccumulative and toxic properties, and have been targeted for "zero discharge".

Median wet weather contaminant concentrations generally exceeded dry weather concentrations by as much as an order-of-magnitude for suspended solids, TP, *E. Coli*, Phenanthrene and PCBs (see Figure 2.2). The pattern of elevated concentrations of these contaminants under wet weather conditions is not surprising given the well documented relationship between flow and suspended solids concentrations, and hence contaminants typically associated with particulate matter. Figure 2.2 demonstrates that the Don River tended to have the greatest wet weather median concentrations of all eight parameters (although Etobicoke Creek had similar concentrations of Cu and Pb). With the exception of wet weather suspended solids (which were fairly uniform at all tributaries other than the Don), the Rouge River tended to have the lowest median contaminant concentrations (although the Humber River had similar concentrations of Pb and TP). This variable pattern reflects the association between differing land use patterns and associated contaminant sources across these six tributaries and their effect on typical concentrations throughout the year.

2.3 Contaminant Loadings

Total wet weather, dry weather, and annual loading estimates for the eight selected contaminants are presented in Figure 2.3.1 as a means of demonstrating the relative contributions of the six tributaries to the Toronto Waterfront. Since these calculations are dominated by flow, a summary of loadings data is presented in Figure 2.3.2 which normalizes annual loadings for drainage basin area as a more diagnostic means of identifying local land use practices or sources which could be targeted for pollution prevention or abatement initiatives.

The largest tributary, the Humber River, contributed the largest annual loadings of suspended solids, TP, Cu, Pb, and PCB. Exceptions to the general pattern of drainage basin size and total contaminant loadings were observed for the Don River which contributed the greatest loadings of *E. Coli* and Aldrin/Dieldrin, and Etobicoke Creek which was the largest contributor of the PAH Phenanthrene.

Figure 2.3.2 diminishes the dominance of flow in comparisons of loadings between tributaries and highlights several anomalies by providing a comparison of relative loadings per unit of drainage basin area. This picture differs considerably from the total loading comparison. Patterns which emerge from this analysis include the following:

(a) Two of the most rural watersheds (the Humber River and the Rouge River) contributed the greatest quantity of suspended solids and TP per unit area while two of the most urban watersheds (Mimico Creek and the Don River) contributed the least;

(b) The greatest unit area contribution of bacteria came from the Don River which is most probably a reflection of the sewer infrastructure (i.e. a combined sewer overflow system) and the limited storm water storage capacity of the watershed (due to its poorly drained soils and its high proportion of paved surfaces and artificial drainage channels);

(c) The Don River and Highland Creek, which have similar land use characteristics (i.e. predominantly residential and industrial/commercial), stand out with respect to their unit area contribution of Aldrin/dieldrin (which may be a reflection of historical use as a soil insecticide to control termites);

(d) There was an enhanced unit area contribution of the PAH Phenanthrene (a fuel combustion product) from Etobicoke Creek and Mimico Creek (particularly Etobicoke Creek) which receive significant drainage from Pearson International airport and which have a relatively large proportion of their watersheds occupied by multi-lane roads; and

(e) Highland Creek and the Rouge River had extremely small unit area contributions of PCB relative to other tributaries.

3.0 CONCLUSIONS AND RECOMMENDATIONS

These water quality results were obtained as near to the lake as possible, and hence cannot by themselves be used identify specific pollution sources. Nonetheless, they can be used to confirm the relationship between varying land use patterns and pollution sources on tributary water quality across the Toronto waterfront. This information can be used to guide future monitoring for improved source identification, as well as to confirm support for a general range of "good housekeeping" preventative measures associated with infrastructure maintenance and construction.

General conclusions and recommendations are as follows:

(1) Although Lake Ontario monitoring indicates the effect of tributary water quality is relatively localized, generally poor water quality conditions were evident at these six tributaries with median concentrations of a wide range of contaminants failing to meet PWQOs, particularly under wet weather conditions;

(2) A significant relationship exists between wet weather events and increased concentrations and loadings of a wide spectrum of contaminants (i.e. there is little evidence of a dilution effect attributable to rainwater);

(3) There is indirect evidence of local sources of persistent, bioaccumulative substances such as Aldrin/dieldrin and PCB;

(4) The well documented relationship between wet weather (high flow) events and increased concentrations and loadings of a wide spectrum of contaminants suggests that stormwater management remains the single most important means of improving water quality in Toronto tributaries as well as the harbour and localized areas of Lake Ontario;

(5) Storm water management measures will need to be accompanied by source identification investigations for high priority contaminants since although reduction of storm water flows reduces the transport of contaminants into tributaries and the waterfront, it does not remove the actual sources of many contaminants.

REFERENCES

Aquafor Beech Limited 1997: *Metropolitan Toronto Wet Weather Outfall Study – Phase III Seasonal Analysis Study*, Unpublished Report prepared for the Metropolitan Toronto and Region RAP.

Cohen, A.C., 1959: Simplified estimators for the normal distribution when samples are singly censored or truncated. *Technometrics*, Vol. 1, No. 3, pp. 217-237.

Dolan, D., Yui, A.K., and Geist, D. 1981: Evaluation of River Load Estimation Methods for Total Phosphorus, *Journal of Great Lakes Research*, Vol. 7, No. 3, pp 207-214.

El-Shaarawi, A.H. and D.M. Dolan, 1989: Maximum likelihood estimation of water quality concentrations from censored data, *Canadian Journal of Fisheries and Aquatic Sciences*, Vol. 46, No. 6., pp. 1033-1039.

Environment Canada, Ontario Ministry of Natural Resources, Metropolitan Toronto and Region Conservation Authority, 1988: *Metropolitan Toronto Remedial Action Plan - Environmental Conditions and Problem Definition*, Ontario Ministry of the Environment.

Gilbert, R.O., 1987: *Statistical methods for environmental pollution monitoring*. Van Nostrand Reinhold Co.

Maunder, D. and Whyte, R. 1995: *Metropolitan Toronto Waterfront Wet Weather Outfall Study – Phase 11 City of Toronto*, Report prepared for the Metropolitan Toronto and Region RAP by Aquafor Beech Limited, Ontario Ministry of Environment and Energy. ISBN 0-7778-4787-6

Ontario Ministry of the Environment (MOE), 1988: *Update Handbook of Analytical Methods for Environmental Samples*.

Paul Theil Associates Limited and Beak Consultants Limited 1995: *Metropolitan Toronto Waterfront Wet Weather Outfall Study – Phase 1*, Report prepared for the Metropolitan Toronto and Region RAP, Ontario Ministry of Environment and Energy. ISBN 0-7778-4786-8

Snodgrass, W.J. and D'Andrea, M. 1993: *Dry Weather Discharges to the Metropolitan Toronto Waterfront*, Water Resources Branch, Ontario Ministry of Environment and Energy. ISBN 0-7778-0596-0

Toronto and Region Conservation Authority 1998: Memorandum from Sonya Meek to Duncan Boyd dated December 17, 1998

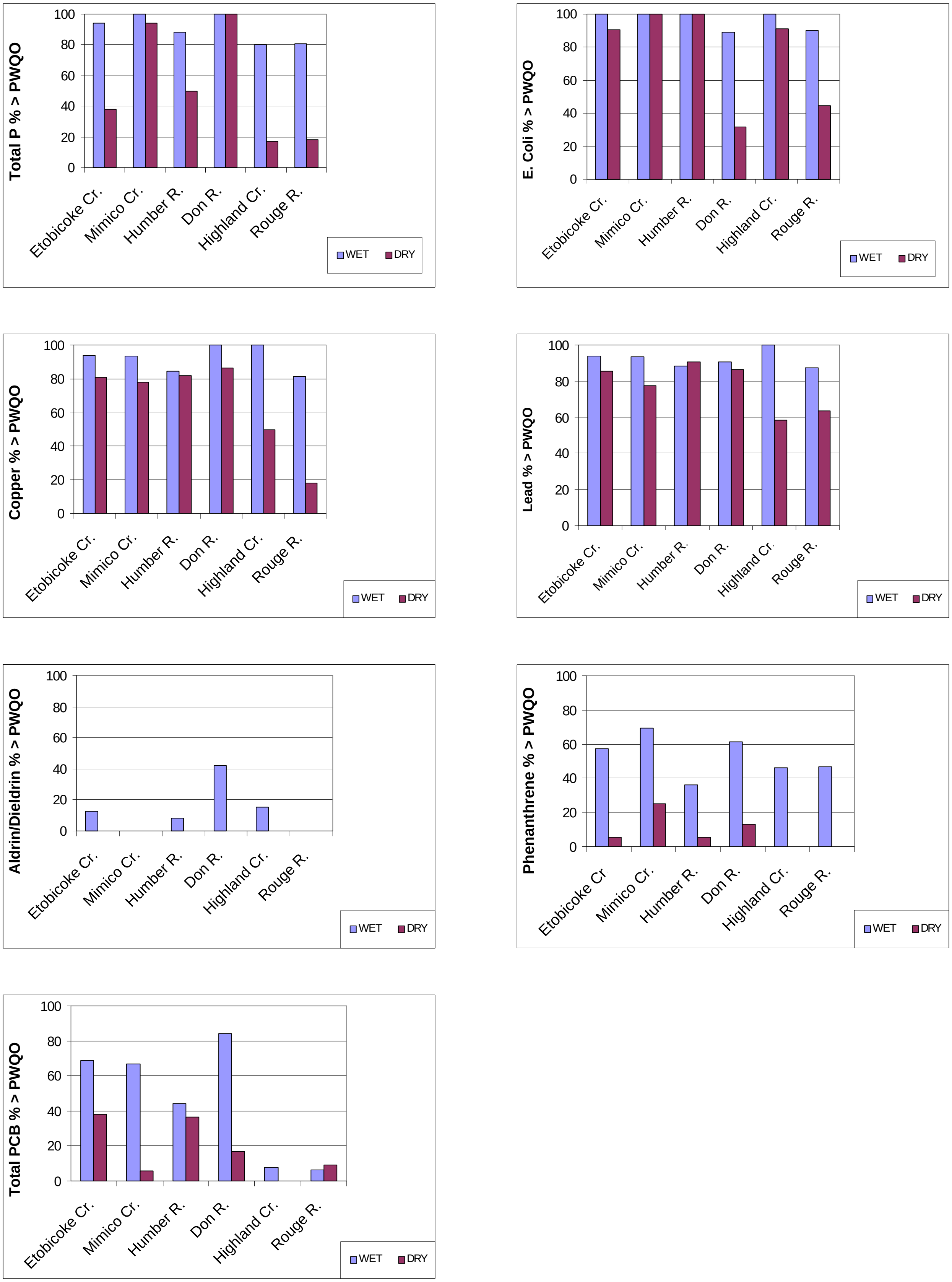

Figure 2.1: **Relative Frequency of Detection Above Provincial Water Quality Objectives for Selected Parameters**

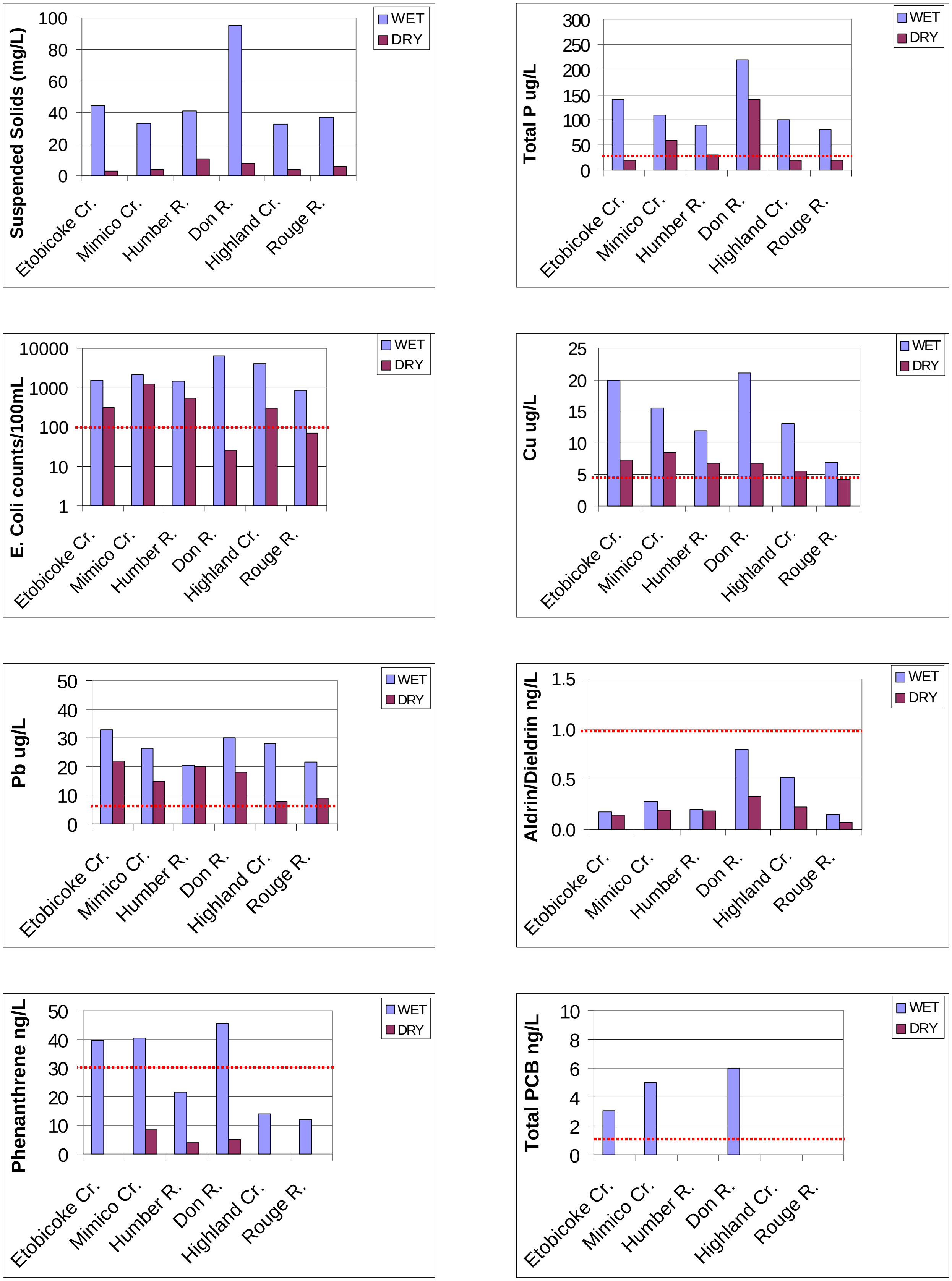

Figure 2.2: Wet and Dry Weather Median Concentrations of Selected Contaminants

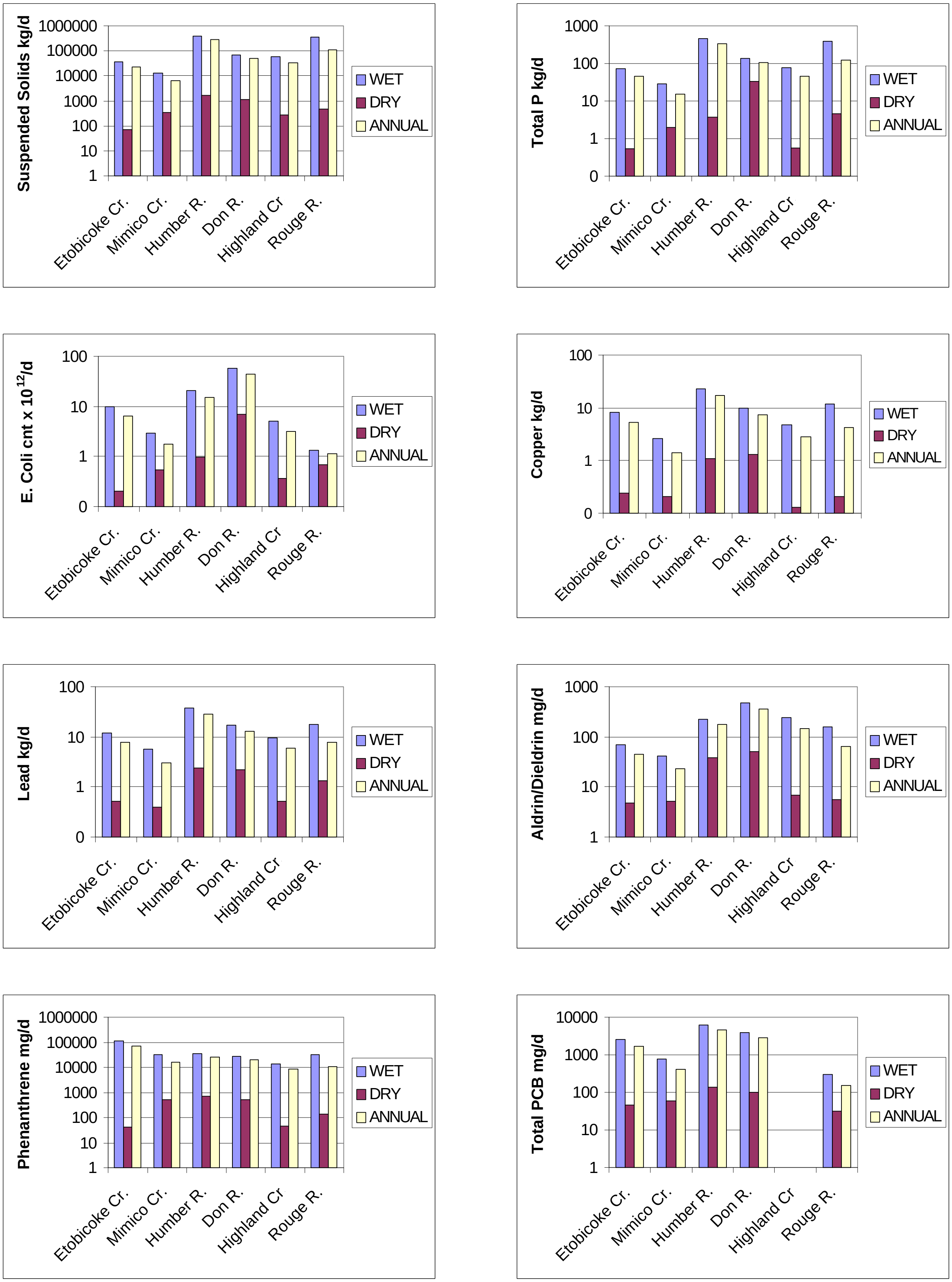

Figure 2.3.1: Summary of Selected Loadings Results

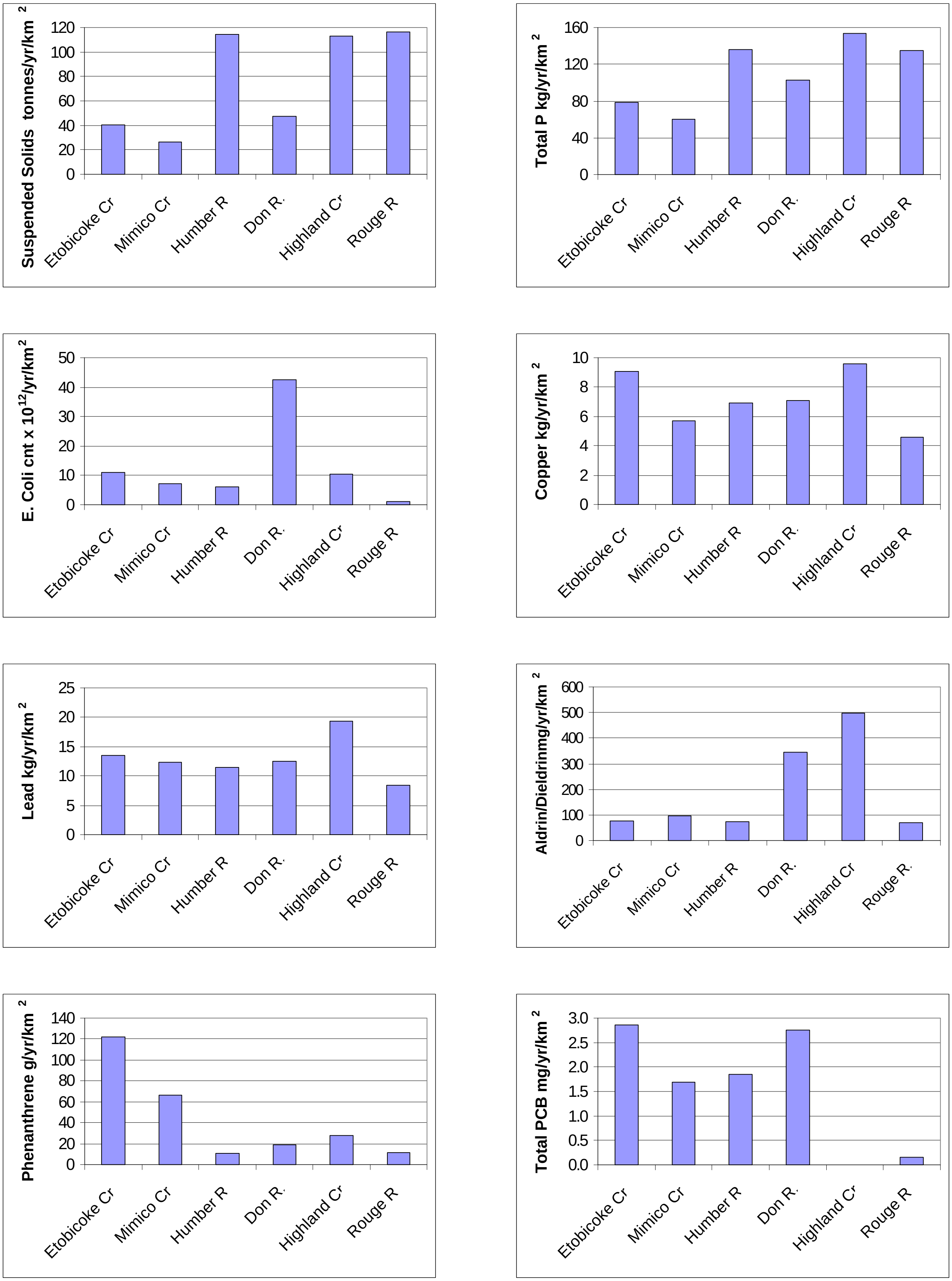

Figure 2.3.2: Summary of Selected Annual Loadings per Unit Area